

SHIP PRODUCTION COMMITTEE  
FACILITIES AND ENVIRONMENTAL EFFECTS  
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EDUCATION AND TRAINING

September 1992  
NSRP 0383

# **THE NATIONAL SHIPBUILDING RESEARCH PROGRAM**

## **1992 Ship Production Symposium Proceedings**

### **Paper No. 6B-3: Integrated Design Packages: The Link Between Manufacturing and Design**

U.S. DEPARTMENT OF THE NAVY  
CARDEROCK DIVISION,  
NAVAL SURFACE WARFARE CENTER

Report Documentation Page				Form Approved OMB No. 0704-0188	
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1. REPORT DATE <b>SEP 1992</b>		2. REPORT TYPE <b>N/A</b>		3. DATES COVERED <b>-</b>	
4. TITLE AND SUBTITLE <b>The National Shipbuilding Research Program, 1992 Ship Production Symposium Proceedings, Paper No. 6B-3: Integrated Design Packages: The Link Between Manufacturing and Design</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Naval Surface Warfare Center CD Code 2230-Design Integration Tools Bldg 192, Room 128 9500 MacArthur Blvd, Bethesda, MD 20817-5000</b>				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release, distribution unlimited</b>					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>SAR</b>	18. NUMBER OF PAGES <b>12</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

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# 1992 SHIP PRODUCTION SYMPOSIUM



SEPTEMBER 2 - 4, 1992  
New Orleans Hyatt Regency  
NEW ORLEANS, LOUISIANA



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601 PAVONIA AVENUE, JERSEY CITY, NJ 07306

Paper presented at the NSRP 1992 Ship Production Symposium, New Orleans Hyatt Regency, New Orleans, Louisiana, September 24, 1992

## Integrated Design Packages:

No. 6B-3

## The Link Between Manufacturing and Design

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### ABSTRACT

The use of product oriented work break down structure is widely accepted as the most efficient ship building strategy for new construction. Much literature has also been published on applying these concepts to overhaul strategies. The intent of this paper is to describe the Philadelphia Naval Shipyard process in applying the concepts of product oriented work break down structure to the overhaul of Naval ships. The specific process described in this paper will be the development of Integrated Design Packages (IDP's). An IDP is the link that will provide an integrated design instruction that incorporates engineering, manufacturing, and producibility attributes into the design product at PNSY. This paper will provide a history of IDP development, describe its uses and also predict future uses. I will try to impress upon the reader the flexibility of the approach by relaying the many different applications of the IDP to date. Photogrammetry will also be addressed as a means of gathering large amounts of shipcheck data needed to develop the IDP. Also to keep things in perspective IDP's are one part of the overall Zone Technology concept that has been implemented.

### ACRONYMS

IDP - Integrated Design Packages  
CAD Computer Aided Design  
CAD/CAM - Computer Aided Design/  
Computer Aided Manufacturing

### BACKGROUND

Conventional drawing development and installation Strategy for the Overhaul of ships have traditionally been by system.

Although the system approach has been gradually changing to a product strategy, it is beneficial to review some of the inherent problems the traditional system approach forces on the mechanic. Traditionally, conventional drawing strategies are developed by system. There are obvious needs for system design. Performance requirements, system integrity and testing all require a system type analysis. However, the next step is critical because after systems performance is addressed, product similarities and geographic constraints should take precedence and be of primary concern to the work instruction. Generally, the transition from a system approach to a product approach does not take place. The traditional approach to work definition i.e., drawings, routings etc. is to continue the system approach. Therefore, drawings, routings, and work instructions are all issued in a system format.

This creates a basic conflict between how work is issued and how work is executed. The mechanics' efficiency is limited by the geographic constraints of his or her surroundings. Bulksheads, ladders and other access interferences into an area limit the ability of the mechanic to do work. In addition, if like work is not identified for the mechanic to accomplish at the same time in his or her geographic area, a great opportunity to realize efficiency of action is lost. The results of issuing and executing work by system are lack of integration, interferences, delays, and rework. This shipyard transitions the system approach into a geographic/product approach using Zone Technology. Under the moniker of zone Technology lies several initiatives. This paper attempts to explain one specific initiative under Zone Technology that is called an Integrated Design Package (IDP) whose benefits are targeted at solving the

Lack of integrated work resultant from a system approach.

## DEFINITION

The definition of an IDP is simple. It is a design document showing all work in a limited area that provides a more producible installation with no major interferences. It consists of an:

- isometric engineering composite.
- composite plan views and arrangements,
- installation views,
- . prefabrication, list of materials, and
- preoutfit.

The isometric engineering composite is the road map to the IDP. It provides the users, which are many, with an "at a glance" idea of the complexity of the project. The isometric is arranged to show the most information possible, taking into account the objects hidden by the isometric view. The isometric also references all other work shown on the IDP. e.g., composites, on which Sheets the installation appear, where prefabrication and preoutfit information appear, etc. Along with the isometric are technical notes required to accomplish the installation.

Composite plan views are probably the most critical phase of IDP development. It is in this phase that producibility concepts are reviewed. However, ephemeral some concepts appear to be, producibility is not one of them. The savings in this phase are real and will be discussed in detail under IDP development.

Installation views and associated list of materials are the next part of the IDP. The installation view shows all locating dimensions necessary for the mechanic to install the components. Separate sheets are provided for this step. A traditional approach might advocate including all locating dimensions on the composites. This argument has merit but after reviewing several composites it was determined that the amount of information becomes so great on the composite that it was not always easy to discern dimensions and that it may lead to the possibility of mistakes. To make it easier for the mechanic, a separate installation section for each IDP is included with easy to read uncluttered information.

Prefabrication is determined in engineering and forwarded to production. Traditionally it was left to the production department's discretion as to what areas were prefabricated. Sadly the history behind this strategy was attributed to the inaccuracies of design documents. Because the production department did not have a high level of confidence in the design drawings, they were first verified to assure the information was correct. Inaccurate design drawings result in incorrect prefabrication pieces that could not be used. The IDPs are developed to a higher degree of accuracy allowing prefabrication information to be taken directly from IDPs without verification.

Also included in an IDP, where applicable, are the preoutfit instructions. Namely, elements that can be installed into structures before erection onto a ship. Anything installed in the shop is usually cheaper and safer to install versus shipboard. IDPs detail what is preoutfitted. Preoutfitting provides tremendous opportunities for cost and schedule savings.

The best way to view an IDP is to envision it as a file of information to install a complex area of a ship. The IDP approach is not used for the entire ship. It is directed at complex areas of the ship that have multiple engineering disciplines and production shops involved that an integrated approach benefits.

## DEVELOPMENT

The development of an IDP is based on shipcheck information. It is important to start with an accurate baseline of information because new systems to be installed must integrate with the existing systems. Because much of the information on an IDP has the potential for prefabrication accurate information is necessary. This requires the area to be verified with shipboard visits, i.e. shipchecks. "As-built" drawings do not provide the necessary accuracy and are not used directly. A shipcheck for an IDP area requires that the existing conditions of a compartment be documented. The IDP area is shipchecked for remaining systems that will not be affected by the overhaul. Generally the compartment structure is shipchecked along with piping, ventilation,

electrical and foundations that will remain. After shipcheck a Computer Aided Design (CAD) model is created showing the existing conditions as determined by shipcheck. This model is the baseline for an IDP.

As new systems are developed they are integrated into the existing model essentially creating a composite model of the area showing both new and existing systems. Although IDP can be developed without the use of CAD equipment, the ability of CAD to manipulate information and communicate to many users makes it essential to this type of project. CAD also affords the potential to automate many aspects of the manufacturing process. This feature will be discussed later.

Once a CAD model has been developed a producibility review begins. The simplest and shortest definition of producibility is an attribute of a design product which allows it to be manufactured effectively with its available facilities. Some attributes that are reviewed for are (Reference I):

- evaluate complexity of design.
- simple measuring.
- simple manual layout,
- work position,
- accessibility.
- proximity of hull structure.
- Straight piping,
- parallel pipes. and
- simple shapes

In general producibility aspects of overhull designs have been ignored. It is the responsibility of the IDP to address this topic. After producibility improvements the model is reviewed for interferences. This step is automated with CAD developed models. The model is checked for "hits" and when identified they are highlighted in the model. These interferences are resolved, forwarded back to the technical code for incorporation into the drawing. Interferences are not limited to hard hits between systems. Other problems such as inadequate maintenance areas accessibility of equipment. door swings. etc. are also reviewed and resolved.

At this point in the IDP development process the model of the compartment is free of interferences and the package is reviewed for manufacturing information.

The IDP is reviewed for prefab opportunities. Piping and ventilation systems are broken into assembly drawings and forwarded to the manufacturing facilities for make up. As mentioned earlier this is a significant departure from a traditional approach of prefab at PNSY. Traditionally, prefab decisions were made in production, which required another set of drawings. In this IDP process assembly drawings are developed directly from the model.

Another manufacturing review is for preoutfit opportunities. Preoutfitting is the installation of foundations, equipment and systems into a large structural unit prior to its attachment to a ship. Preoutfitting has proved to be very cost effective in that anything worked in the shop versus shipboard tends to be a safer and less costly installation. When applicable, the IDP provides preoutfit instructions which tell the production shops which assemblies are to be preoutfitted.

## GOALS

There are many objectives to this philosophy. Primarily IDPs create an interference free work area with the resultant benefits of minimizing rework or delays. The IDP also attempts to provide the mechanic with an easier product installation by reviewing producibility aspects of design. By being developed on CAD equipment it creates an electronic database of information that can be shared among many users. The information is shared among various engineering sections as well as with production and manufacturing sections. The IDP acknowledges the product approach to engineering in that it shows all work in an area, not just a system by system installation. This allows like work to be identified, scheduled, and planned more efficiently. The IDP acknowledges the physical constraints of the work site by providing a work package in a defined area of the ship in which mechanics can accomplish a number of tasks without leaving the work site.

In addition there was an unexpected gain in the area of field support. When problems arose in compartments for which IDPs were developed, the changes, if required were able to be made quickly and in an informed

manner. This benefit can be directly attributed to comprehensive knowledge the IDP designer has of the IDP compartment. The designer knows what the impacts of change will be to all other systems and is also able to decide quickly which alternative provides the least disruption to the space.

## SELECTION CRITERIA

What makes a compartment a good candidate for the development of an IDP? Large Complex alterations tend to be good candidates for this type of effort. These are areas that a failure or delay in completion would cause a major impact on the project. In addition, historical data may indicate areas that are critical and will likely effect problems. Other considerations are preoutfit opportunities. Preoutfit is actively solicited because of the potential savings that can be realized in this area. Compartments are good candidates for IDPs if many different engineering and production shops are involved. This integrated approach along with the interference control allows for a more organized and directed approach toward compartment completion. Also, compartments that are gutted provide opportunities for IDP development.

## EXAMPLES/HISTORY

The IDP process began with two test projects to validate the CollCept. The first two projects were accomplished for the air conditioning plant installation on the CV-63. USS Kitty Hawk (see figure I ). As can be seen from the figure the composite is strictly a piping composite. no other detail information is included. At the time of development of the IDP the experience of the CAD operators was limited to piping. In addition, the CAD software was relatively undeveloped in other areas of modeling such as ventilation. However rudimentary the initial packages were, positive feedback was received from the production department. There were fewer installation problems in the two compartments for which IDPs were developed.

The next generation IDPs were developed for the USS Constellation, CV-04 (see Figure 2). IDPs were developed for air conditioning plant installations, rotary retraction installations, radar installations and various other installations. A total of twenty IDPs were developed. It is obvious that at least

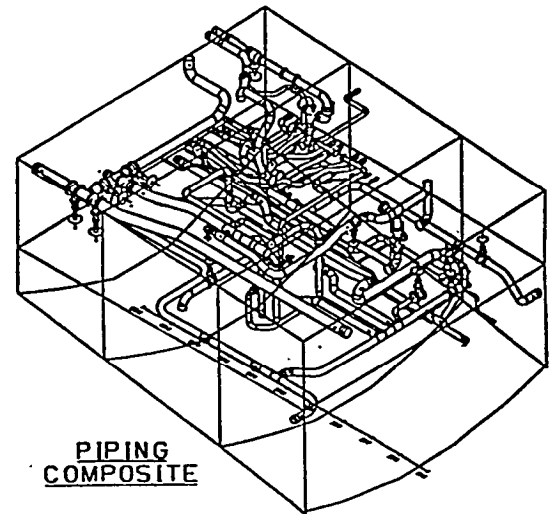
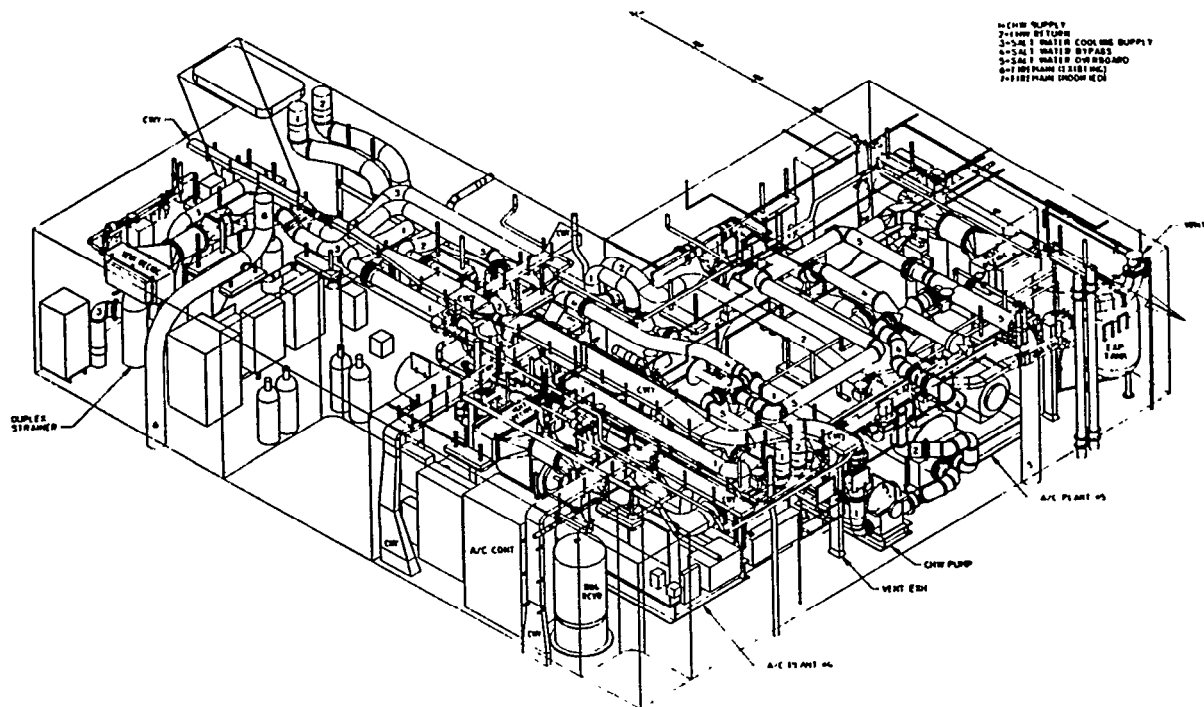


Fig. I CV-63 Piping composite.  
Air conditioning piping

the knowledge of modeling increased from the first efforts. This particular model (Figure 2) includes not only piping but also ventilation, cableways, equipment, lighting and foundations. This model is more complete, approaching the goal of a composite showing all information, integrating the entire design, and providing prefabrication information, all directly developed from the CAD model. The IDPs are developed on full size drawing sheets to show all the necessary details.

Figure 3 is an IDP which provided information for ventilation along with a full structural, piping, ventilation and cableway model. Figures 4 and 5 are plan views of this model showing composites. These figures (3, 4, and 5) show all systems being installed in the compartment and was a great improvement over the initial IDPs described earlier. Figure 4 illustrates a simple benefit of an integrated approach that is not always obvious. Lighting fixtures are often the first hardware to be installed during the availability for the obvious necessity. Historically the lights are installed and modified numerous times during the availability because of continuing interferences. Once the composite is completed and checked for interferences the light locations are determined and can be installed without the need for modification due to interferences. This is a simple but effective application.





COMPOSITE  
 A/C MACHINERY RM #4 AND #5  
 3-119\_0-1

Fig. 2 CV-64 Integrated Design Package composite

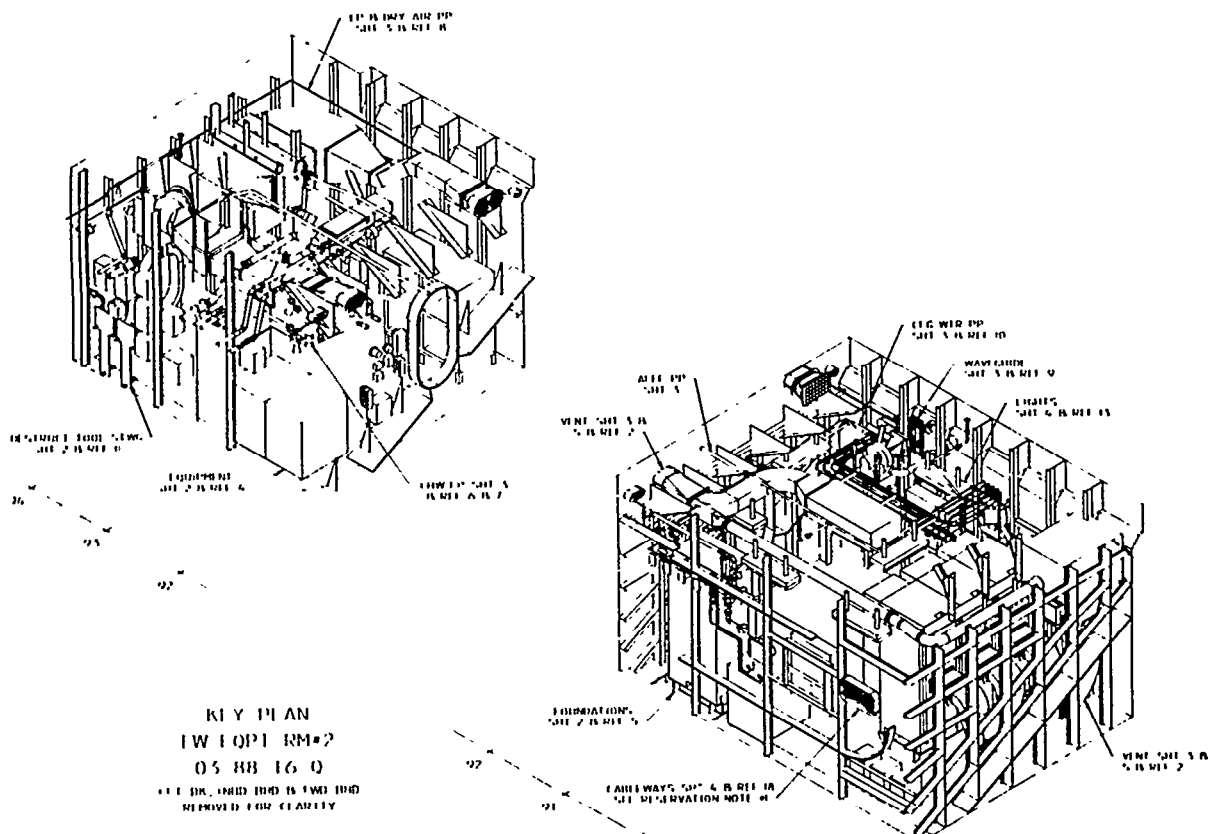


Fig. 3 CV-64 Integrated Design Package composite E.W. Eq. Room #2

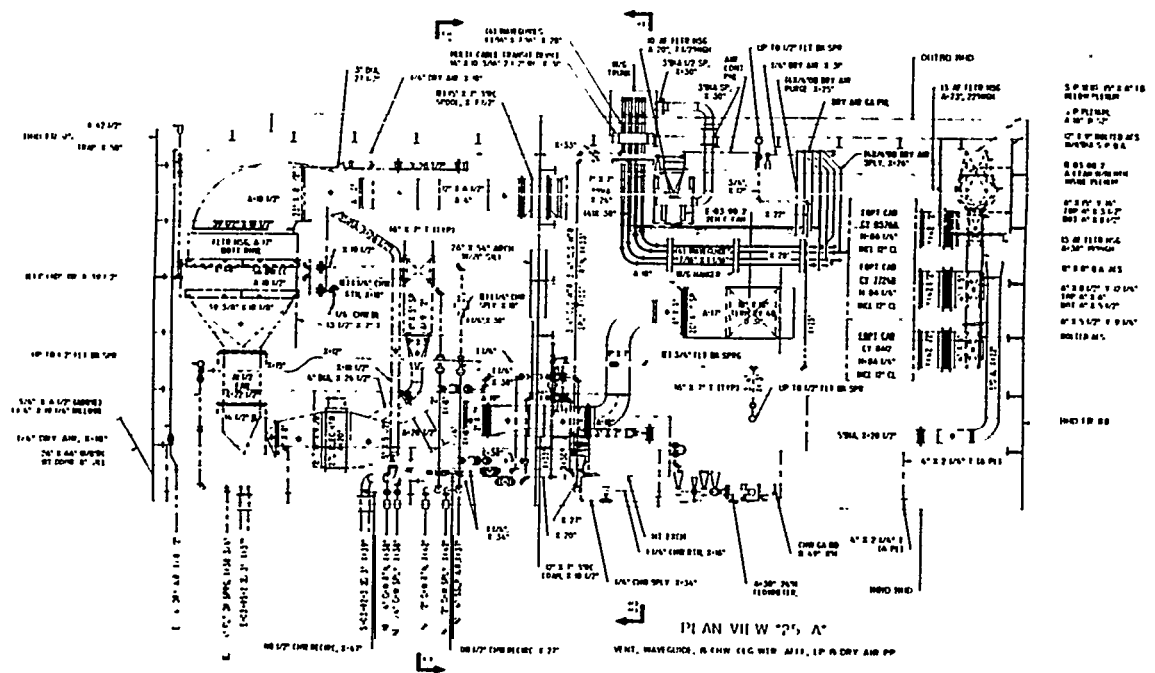


Fig. 4 CV-64 Plan view E.W. Eq. Room #2 from model.

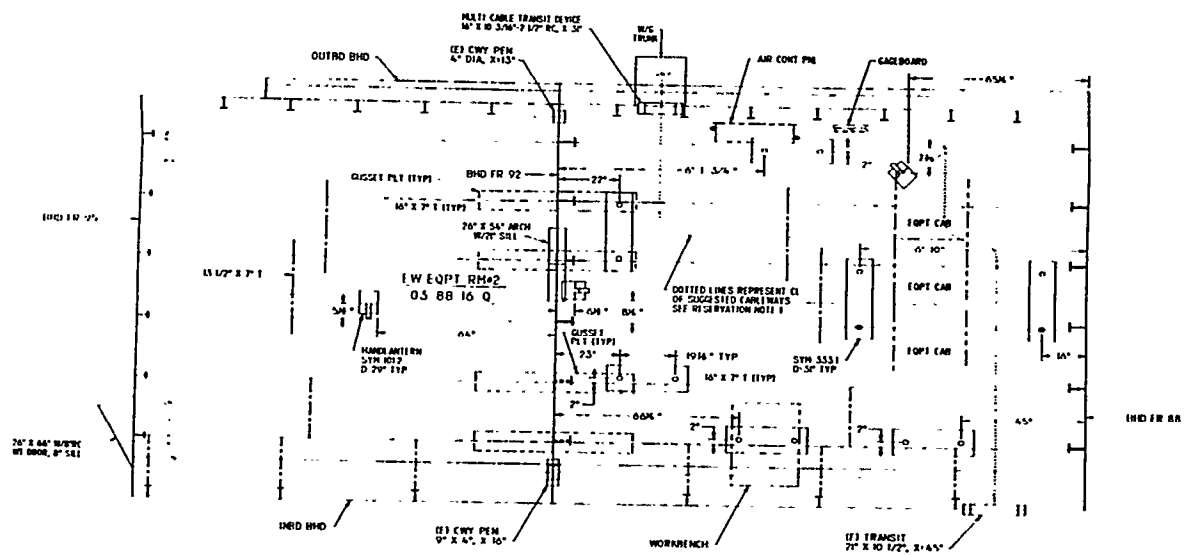


Fig. 5 CV-64 Plan view E.W. Eq. Room #2 from model.  
(lighting and cableways)

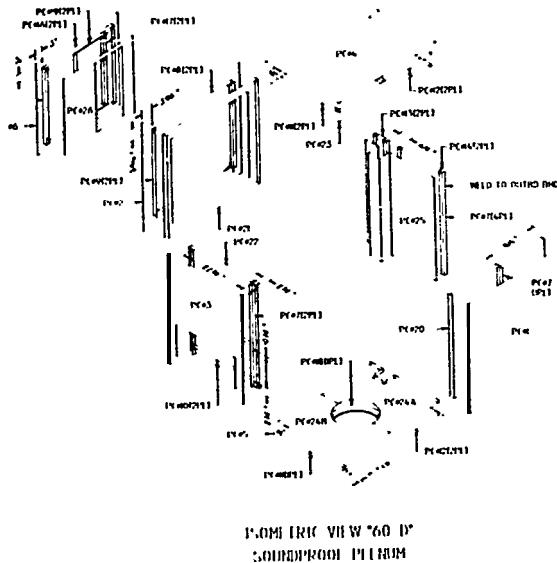


Fig. 6 CV-64 E.W. Eq. Room fabrication detail

Figure 6 is the detailed fabrication information for a ventilation plenum. The point to be emphasized with this example is the flexibility of the information that can be developed once the model is created. This type of information would never have been provided from the engineering division.

#### OPPORTUNITIES

Integrated Design packages provide many opportunities for improved work. They provide opportunities to enhance the sequencing of work. Since an IDP Shows all work in an area it allows for planning schedule and sequence work more efficiently.

Other opportunities exist in Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) interfaces. Since IDPs are developed on CAD equipment, more opportunities exist to pass the information electronically to the manufacturing and production departments. There is no need to recreate information for CAM development if it has already been developed in engineering. The other benefit is that all departments work from the same baseline information. In addition to maximizing CAD/CAM usage another opportunity exists to maximize the uses of IDP information in planning. Its effect at

every opportunity the information should be shared. The electronic information developed for the IDP can be used in the entire planning process as well as manufacturing and production. For example the IDP can be used by other engineering disciplines in developing drawings. The information can be passed to material ordering, work packing, scheduling, and estimating. Sharing information also intrinsically standardizes the information. The goal is to create the information once in a format that satisfies all user requirements.

Photogrammetry has also provided the opportunity to gather the large amount of shipcheck information necessary to develop an IDP. In essence, photogrammetry lends itself nicely to shipcheck applications because of its ability to gather information accurately. With the use of photogrammetry to gather shipcheck information and CAD/CAM to transfer data from engineering to manufacturing, a complete electronic transfer of information is realized.

#### FUTURE

It is the intent of the IDP process to maximize CAD/CAM transfer of information. In addition, the use of photogrammetry to gather large amounts of information is a prime area of investigation. This technology may provide the vehicle to cheaply gather large amounts of information that will allow more IDPs to be developed. IDPs are shipcheck intensive but the use of photogrammetry to shipcheck may resolve this problem.

Producibility has only been addressed superficially. This is the one area where the greatest return on investment may come.

More attention needs to be focused on how a mechanic performs his or her work and how the engineering design supports their efforts. All too often existing designs are reused without at least a circumspect look to see if it is indeed efficient. To date the IDP has been only at the tip of the iceberg in this area.

The use of CAD II equipment is also eagerly anticipated. CAD II is the new hardware/software Computer Aided Design equipment being purchased by the Navy to replace existing antiquated equipment. This

new hardware will also speed the IDP process. With the old CAD hardware the development time would increase with the number of components in the model. Large complex models would generally take an inordinate amount of time to recreate

The process is continually being refined to standardize, simplify and share information. Compartments that have had the IDP process applied have been successful production installations which has encouraged further projects on future ships. Above all and not to be forgotten is the human resources to make the IDP process work. Dedicated, knowledgeable personnel are the key ingredient to IDP development.

## SUMMARY

The integrated Design Package has proven to be a cost effective method of increasing production efficiency by improving the quality of the engineering product. The essence of the process is to integrate the system by system approach into a composite model. The integration that allows the designer to address certain attributes of the design that can not always be accomplished in the traditional system approach. These models must be accomplished on CAD for numerous reasons. CAD affords the designer the flexibility to manipulate information. It also allows the information to be shared. Not only can the information be shared among the engineering division, it can also be shared in production via CAM interfaces. The important attributes that must be achieved in any design are standardization, simplification, and shared information. The Integrated Design Package is the vehicle the Philadelphia Naval Shipyard uses to achieve these principles.

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